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MEETING HIGHLIGHTS

Highlights of the Second Annual Scientific Meeting of the Society of Cardiovascular Computed Tomography

Washington, DC, July 6–8, 2007

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Los Angeles, California; Erlangen, Germany; Washington, DC; and New York, New York

The second annual meeting of the Society of Cardiovascular Computed Tomography (SCCT) was held in Washington, DC, on July 6 to 8, 2007. From an organizational perspective, several new milestones were reached at this meeting. The first issue of the *Journal of Cardiovascular Computed Tomography*, edited by Dr. Allen Taylor, was published, along with a supplement containing all abstracts of original scientific work presented at the meeting. The kick-off of the first multimember randomized clinical trial initiated through the efforts of the SCCT was announced. With Dr. Gil Raff as principal investigator, the CT-STAT (Systematic Triage of Acute Chest Pain Patients to Treatment) trial will compare coronary computed tomography (CT) angiography to rest/stress nuclear cardiology studies in 750 patients presenting to the emergency department with acute chest pain, with a focus on patients at low risk in whom safe, early discharge from the emergency department might be achieved with CT. The Certification Board of Cardiovascular CT was announced, which plans to offer the first certification examination in cardiac CT in September 2008, and the SCCT announced plans for a 2-day board preparation course to be held before that date. The second annual meeting was attended by 750 registrants. There were 83 invited lectures, 10 "Read with the Expert" sessions, 8 moderated case demonstration sessions, 32 oral abstract presentations, and 76 poster presentations.

In an introductory plenary lecture, Dr. Robert Bonow emphasized the importance of the quality initiative of the American College of Cardiology and the need to insure that the highest-quality standards are applied and documented in all aspects of cardiac CT, including appropriate patient selection, acquisition and processing of studies, interpretation, and reporting. He also stated that patient selection will be the key to the success of cardiac CT and suggested that, when appropriately used, CT has the potential to favorably impact downstream testing procedures and costs. Noting that measuring performance in cardiac imaging is important, he pointed out that connecting performance of an imaging test to health-related outcomes is inherently difficult—but that this can be achieved in part by documenting the impact of testing on clinical management.

From a scientific perspective, several new potential clinical applications of CT in cardiac imaging as well as new technologic developments were presented. Dr. Al Lardo presented data showing the ability of cardiac CT to quantify regional myocardial perfusion at rest and during adenosine stress with approaches similar to what has been developed for cardiac magnetic resonance imaging. Although stress perfusion with CT is of potential interest, it clearly remains investigational at this time. The difficulty of using the same contrast injection for the coronary CT angiogram and the adenosine myocardial perfusion assessment was discussed. When used, adenosine increases heart rate, even in patients on beta-blockers and, with current scanners, this increase in heart rate could compromise the quality of the coronary CT angiography portion of the study as the result of coronary artery motion. Nonetheless, the ability to assess stress myocardial perfusion and coronary anatomy at the same time could be of great clinical value (Fig. 1).

Dr. Lardo also presented the initial animal and clinical work performed in the U.S. with a 256-slice CT scanner in which the entire heart can be imaged in a single beat, providing the potential to dramatically reduce radiation dose. Sequential low-dose images could allow 4-dimensional quantitative assessment of myocardial perfusion through acquisition of whole heart data from sequential cardiac cycles. Conceptually, a single examination could allow comprehensive assess-

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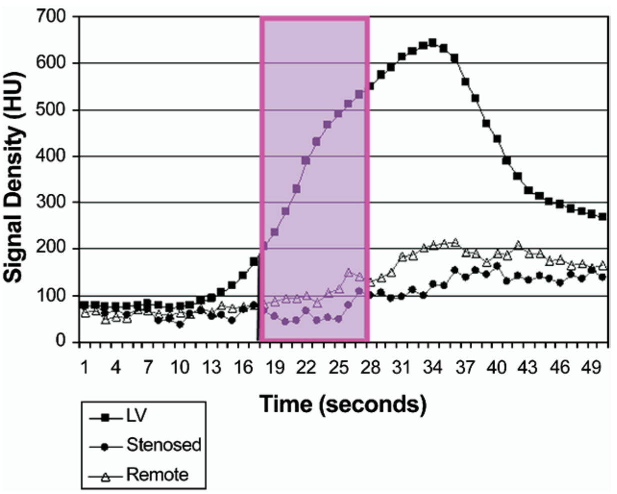

Figure 1 **Dynamic Multidetector Computed Tomography Scanning of Perfusion**

Myocardial time-density curves were measured from the anterior myocardial wall (stenosed) and the inferior myocardial wall (remote). A canine model of left anterior descending artery stenosis during infusion of adenosine and intravenous iodinated contrast. **Vertical lines** illustrate the period that helical multidetector computed tomography scanning took place. LV = left ventricular. Adapted with permission from J Am Coll Cardiol 2007;48:153–60.

ment of coronary anatomy, cardiac function, myocardial perfusion and, from delayed images, myocardial viability.

A novel approach to potentially reducing the problem that dense coronary calcium can cause in coronary CT angiography was presented as a work in progress by Kuribayashi et al. (1). By using a new type of detector material, this technology could provide the capability to accurately subtract out coronary calcium by separately binning the photon data from low- and high-energy X-rays. The ability to successfully subtract dense coronary calcium and successfully visualize the coronary lumen was demonstrated in ex vivo coronary images (Fig. 2).

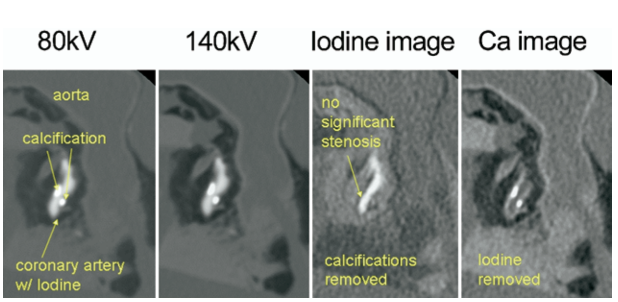

Figure 2 **Ex Vivo Dual-Energy Images of an Atherosclerotic Coronary Artery Using a Prototype Scanner**

From **left to right**: 80-kV image, 140-kV image, iodine image after calcification removal, and calcium (Ca) image after iodine removal. Courtesy of Dr. Sachio Kuribayashi, Keio University School of Medicine.

Several abstracts dealt with sources of artifact on CT, with the principal source being coronary motion. Donnino et al. (2) compared dual- to single-source coronary CT angiography and demonstrated that with either scanner motion artifact was more frequent with increasing heart rates. At every heart rate assessed, however, the dual-source scanner provided a clear reduction in the frequency of moderate-to-severe motion artifact compared with that observed when a single-source 64-slice CT scanner was used, because of the 2-fold improvement in temporal resolution provided by the dual source scanner. Dey et al. (3) reported that although overall artifacts are not entirely eliminated with dual-source 64 slice scanners, it was uncommon for a study to be considered uninterpretable, with none of an initial study of 180 patients having an unevaluable study.

Multiple methods to reduce radiation dose were presented in the abstracts. Impressive results were shown by Pflederer et al. (4), who reported that in patients with <85 kg body weight, a 20% reduction in tube voltage (using 100 kV instead of the standard value of 120 kV) resulted in a 39% reduction of effective radiation dose to the patient with no loss of image quality. The approach appears to be preferable in nonobese patients, and many investigators reported plans to immediately implement this protocol adjustment.

Various approaches to prospective gating with "step and shoot" as opposed to spiral CT acquisition were shown (Fig. 3), resulting in reduction of radiation dose with coronary CT by nearly an order of magnitude less than that associated with the standard retrospective gating approach. The dose reduction is possible because of the ability with prospective gating to eliminate slice overlap that is inherent in spiral CT and to the fact that the X-ray tube is active for only a short time (mean 0.98 s), as presented by Earls et al. (5). Figures 4 and 5 show examples of prospective gating

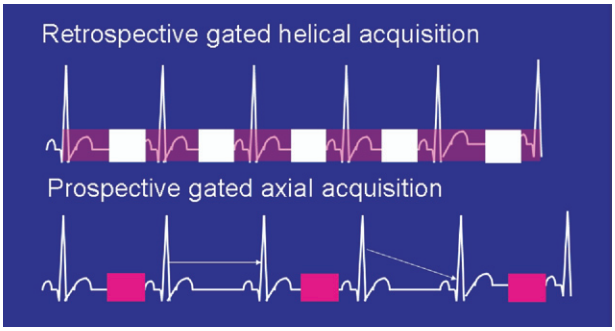

Figure 3 **Diagrammatic Representation of Retrospective Versus Prospective Gating**

(Top) Retrospective gating; **(bottom)** prospective gating. With prospective gating, the tube current is on only for the predefined portion of the cardiac cycle (here shown to be ~40% of the cycle, but as low as 1/10th to 1/5th of the cardiac cycle [83 to 200 ms] is currently achievable). **Arrows** shows 100% of cardiac cycle. Courtesy of Dr. Nadeem Hussain of University of South Alabama.

shown at the conference. At the present time, the prospective gating technique requires a patient with a low heart rate and regular rhythm and does not allow assessment of ventricular function.

Dr. Michael Poon, the incoming president of the SCCT, and Dr. Stephan Achenbach, the first and outgoing president of the SCCT, presented initial data showing that, with extensive post-processing, even patients with atrial fibrillation can be evaluated with coronary CT angiography. However, both authors stated that, with most scanners, atrial fibrillation is still considered a relative contraindication to coronary CT angiography because of the high frequency of nondiagnostic studies that may arise as a result of the effect of variation in beat length during acquisition on scan quality.

From the clinical perspective, among the most compelling data presented were in a review given by Drs. Joao Lima and Jeffrey Carr on results from the MESA (MultiEthnic Subclinical Atherosclerosis) trial. They presented work from Detrano et al. (6), who reported previously at the American College of Cardiology scientific sessions in 2007, showing that coronary calcium is a stronger predictor of cardiac events than Framingham risk scoring in 4 ethnicities (all of those studied). Importantly, and possibly for the first time, a coronary calcium score of 1 to 100 was demonstrated to be associated with a greater risk-adjusted hard event rate than patients with a coronary calcium score of 0.

Although a coronary calcium score of 0 confers an excellent prognosis in asymptomatic patients, data supporting caution regarding prognostic statements in symptomatic

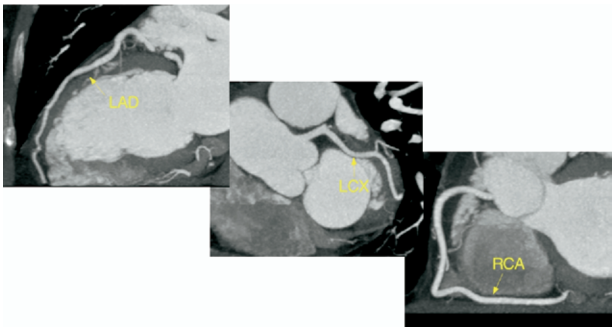

Figure 5 **Selected Curved Multiplanar Reconstructions Using Prospective Gating**

A 54-year-old female with hypercholesterolemia (Siemens, Definition). 2.4 mSv = radiation dose; LAD = left anterior descending artery; LCX = left circumflex coronary artery; RCA = right coronary artery. Courtesy of Cedars Sinai Medical Center.

patients with a coronary calcium score of 0 were presented by Jarreau et al. (7) These investigators reported that coronary stenosis by CT angiography was observed in 12% of symptomatic patients with no CT evidence of coronary calcium. Although the prevalence of obstructive, solely noncalcified plaque in patients with chest pain from this study is greater than in previous reports, this type of observation has created consensus that coronary CT angiography rather than noncontrast CT for coronary calcium would be the appropriate cardiac CT approach for patients presenting to the emergency department with acute chest pain.

It is widely recognized that coronary CT angiography tends to overestimate coronary stenosis severity. Akram et al. (8) presented interesting work in this regard from the ATLANTA (Assessment of Tissue characteristics, Lesion morphology and hemodynamics by Angiography with fractional flow reserve, intravascular ultrasound and virtual histology and Non-invasive computed Tomography in Atherosclerotic plaques) trial in progress. This trial is designed to study (for research purposes in consented patients) invasive quantitative coronary angiography, fractional flow reserve, and intravascular ultrasound procedures performed at the time of catheterization in patients found to have intermediate coronary stenoses by coronary CT angiography. In 20 such patients studied to date, Voros et al. (8) reported that CT findings that are predictive of abnormal fractional flow reserve, widely accepted as a clinical standard for significant obstruction, included a diameter stenosis of ≥77%, luminal area stenosis of ≥60%, minimal lumen diameter of 0.89 mm, and a minimal luminal area of 3.0 mm^2.

Dr. Jack Ziffer discussed the importance of combining information of coronary anatomy with that provided by stress myocardial perfusion assessment in selected patients (9). He noted that the recent COURAGE (Clinical Outcomes Utilizing Revascularization and Aggressive Drug

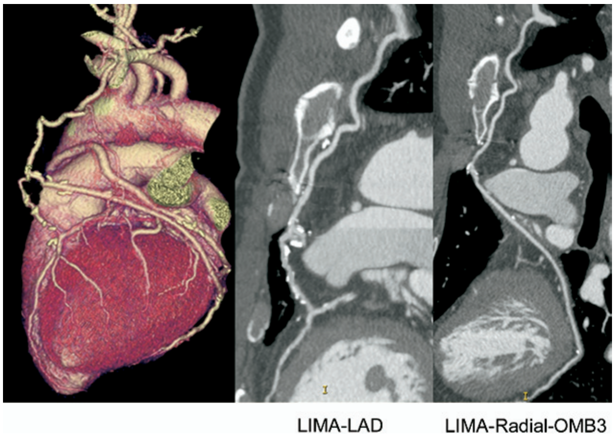

Figure 4 **Volume Rendered and Curved Multiplanar Reconstructions Using Prospective Gating**

Volume rendered **(left)** and curved microplanar reconstructions **(middle and right)** of a 47-year-old male with equivocal single-photon emission computed tomography 5 years after coronary artery bypass grafting (GE, Discovery VCT). The graft, anastomoses, and distal coronaries are widely patent. 3.87 mSv = radiation dose; LIMA-LAD = left internal mammary artery to left anterior descending; LIMA-Radial-OMB3 = Lima-radial artery graft to the third obtuse marginal branch (OM3). Courtesy of Dr. James Earls, Fairfax Radiological Consultants, Fairfax, VA.

Evaluation) trial, showing the absence of a reduction of cardiac events by percutaneous coronary intervention (PCI) combined with optimal medical therapy over the results of optimal medical therapy alone provided a warning to clinicians to avoid the temptation to consider all stenoses observed on coronary CT angiography as needing to be followed with PCI (the "occulostenotic reflex"). Dr. Ziffer also illustrated that combining information from CT with that of myocardial perfusion single-photon emission computed tomography (SPECT) or position emission tomography (PET) could lead to improvement in accuracy of each method, potentially having a compounded beneficial effect on the overall accuracy of combined testing. He noted that this combined testing is needed only when the results of the initial test do not provide adequate information to guide patient management. In this regard, myocardial perfusion SPECT or PET after a borderline or nondiagnostic coronary CT angiogram can define the hemodynamic significance of lesions and the identify the culprit vessel, whereas CT angiography can improve the accuracy of SPECT and PET by allowing more accurate assignment of myocardial contours and individualized assignment of perfusion defects to individual coronary lesions (Fig. 6).

Regarding assessment of clinical outcomes after coronary CT angiography, Min et al. (10) compared private-payer administrative claims with complete facility, physician, and pharmacy data from 2 large health care plans for 2002 to 2005. One of the concerns about coronary CT angiography is that it might add expense without eliminating other testing or costs. These investigators reported a study of 1,833 patients undergoing CT angiography and 7,332 patients undergoing SPECT myocardial perfusion imaging as their initial diagnostic screen for CAD, representing a matched patient population of patients without known CAD. Despite the early period in which these data were collected relative to clinical experience with coronary CT angiography, the cohort initially tested with CT incurred CAD-related costs that were $1,716 (95% CI 361 to 4,649) lower than myocardial perfusion imaging during the 12 months after initial coronary evaluation, principally because of reduced downstream testing. There were also lower rates of CAD-related hospitalization, MI, and subsequent reporting of angina.

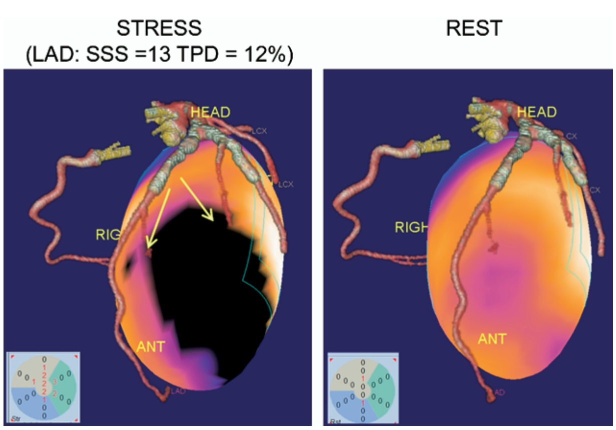

Figure 6 **Volume Rendered 64-Slice CCTA Fused With SPECT Obtained on a Different Scanner at a Different Time**

Singe-photon emission computed tomography (SPECT) showing ischemia (3-dimensional blackout region on the **left**). Stress total perfusion (TPD) was 12% in the territory supplied by the diagonal branches of the left anterior descending artery (as anatomically determined by computed tomography angiography [CCTA]). LAD = left anterior descending; SSS = summed stress score. Courtesy of Slomka PJ, Suzuki Y, Elad Y, et al. Software fusion of 64-slice CT angiography and myocardial perfusion SPECT: evidence of synergy. Society of Nuclear Medicine 2007 Annual Meeting; June 2–6, 2007; Washington, DC, Abstract 17.

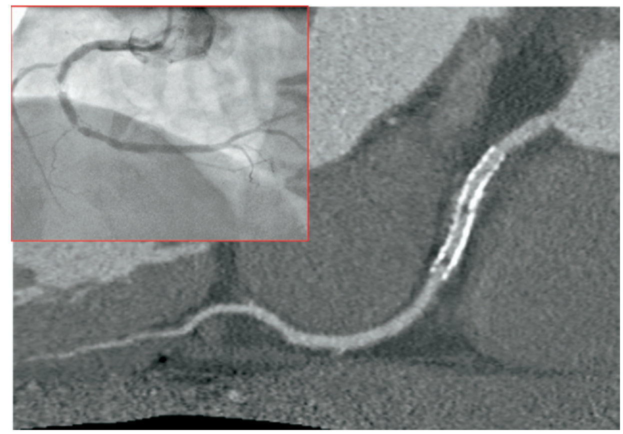

Figure 7 **Curved Multiplanar Reconstructions From CCTA in a Patient With a Right Coronary Artery Stent**

Two discrete regions of absent contrast are found within the stent which correlated with in-stent stenoses observed by subsequent invasive coronary angiography **(left corner)**. CCTA = coronary computed tomography angiography. Courtesy of Dr. Stephen Achenbach, University of Erlangen, Germany.

Karlsberg et al. (11) reported the frequency of various diagnostic procedures in a large cardiology group practice, before and for 1 year after the addition of 64-slice CT to the practice. Of note, when compared to the 6-month period before CT angiography, the number of patients undergoing myocardial perfusion SPECT during the initial and subsequent 6-month periods after introducing CT angiography was reduced by 14% and 15%, respectively. Although the frequency of invasive coronary angiography was little changed, there was an increase in the proportion of patients who underwent a PCI procedure during catheterization, suggesting improvement in patient selection for catheterization.

Regarding clinical applications of coronary CT angiography, Dr. Achenbach observed that in highly selected patients (Fig. 7), CT may provide information regarding in-stent thrombosis, and importantly the absence of in-stent thrombosis or stenosis. He also cautioned, however, that coronary CT angiography in stented patients is exquisitely sensitive to artifacts; especially even slight amounts of motion within the coronary stent (Fig. 8). He concluded

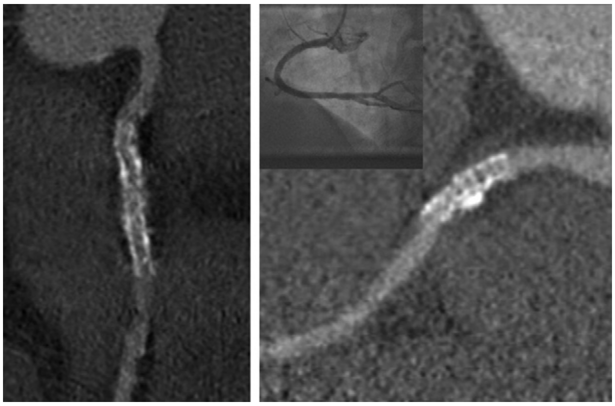

Figure 8 **Curved Multiplanar Reconstructions From CCTA in a Patient With a Right Coronary Artery Stent**

Two areas of "apparent" moderate decrease in contrast are noted. The regions are less discrete than in the patient shown in Figure 7. The corresponding invasive coronary arteriogram **(left corner)** showed no evidence of in-stent stenosis. In retrospect, the false-positive CCTA study was attributed to slight degree of right coronary artery motion during the CCTA acquisition. Courtesy of Dr. Stephen Achenbach, University of Erlangen, Germany.

that, in very selected situations, CTA may be useful for assessment of in-stent restenosis. He further cautioned that for this application, all imaging conditions have to be optimized. Heart rate, noise, stent size play major roles, and he recommended that only stents ≥3.5 mm in diameter be subject to this assessment. He noted, however, that better temporal and spatial resolution will help visualize smaller stents in the future.

Achenbach also noted that the ability of CT to visualize noncalcified coronary atherosclerotic plaque is promising. However, he pointed out the paucity of clinical data concerning the predictive value of such plaques for cardiac events. Potential markers of plaque vulnerability that might be identified by CT include large plaque volume, positive remodeling, and possibly large amounts of lipid (based on CT density within the plaque) (Fig. 9). Dr. Jeffrey Carr demonstrated that the pattern of speckled calcification in coronary CT imaging may be associated with increased risk (Fig. 10), and an abstract supporting this concept was presented by Motoyama et al. (12).

Although there are few prognostic data specifically regarding noncalcified plaque and coronary CTA at present, the results of a small prognosis study that has been reported was presented by Dr. Joanne Schuijf (Fig. 10) (13). The presence of an abnormal coronary CT angiography without stenosis was shown to have an intermediate rate of cardiac events between the high rate in patients with stenosis and the absence of events in patients without abnormality on coronary CT angiography; however, the number of patients in the study was small, there were relatively few cardiac events, and only 6 events were reported in patients with the mildly abnormal CT angiography group. The need for further data in this regard is evident.

Dr. Daniel Berman discussed how to report plaque in otherwise-normal coronary CT angiography studies and what to recommend. He noted that because global coronary calcium scores were of proven prognostic value, global scores for noncalcified and mixed plaque should be developed as part of the process of developing the prognostic capabilities of coronary CT angiography. There currently are no standardized scores to reflect the burden of noncalcified or partly calcified plaque observed by coronary CT angiography. In this regard, interesting preliminary data have been reported by Min et al. (10), in which a segmental involvement score, an early attempt to provide a global assessment of the results of coronary CT angiography, was effective in separating high- and low-risk subgroups in patients followed for more than 1 year after coronary CT angiography (Fig. 11).

In plenary lectures regarding future developments in CT technology and clinical application, Drs. Poon and Carr described several emerging technical advances in cardiac CT. Showing developments in progress with each of the major manufacturers, both provided irrefutable evidence that the technology of cardiac CT is improving at a rapid rate. They predicted that the assessment of coronary plaque will play an important clinical role and that cardiac CT "models" will be used to guide minimally invasive therapies of the future. In the more immediate future, coronary CT angiography will likely be used to guide interventional procedures such as radiofrequency ablation of atrial fibrillation, sizing of stents, optimizing views for invasive coronary angiography, and planning of approaching stents for chronic total occlusions. Additionally, tissue characterization, novel

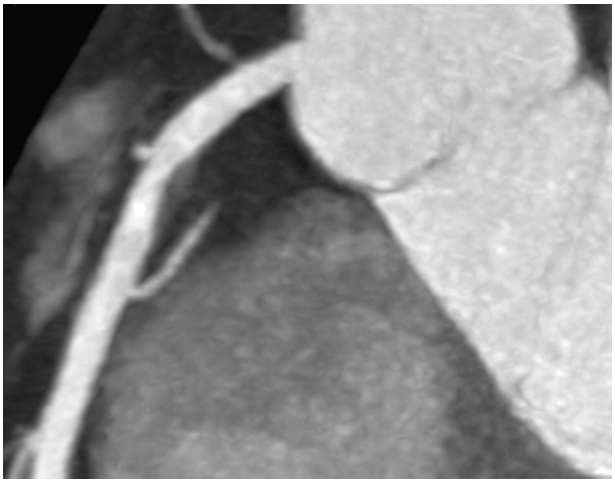

Figure 9 **Long-Axis Maximal Intensity Projection Image From a CCTA**

Minimal coronary narrowing associated with a large noncalcified plaque that has resulted in positive remodeling of the artery wall. Courtesy of Dr. Stephen Achenbach, University of Erlangen, Germany.

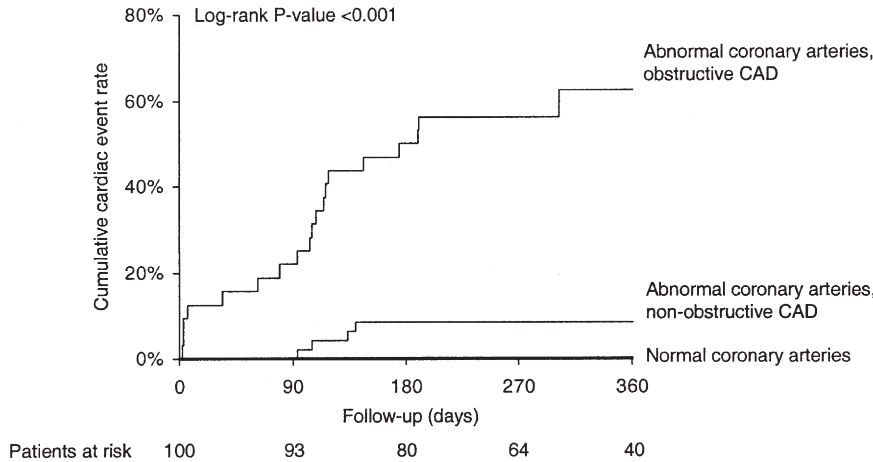

Figure 10 **Prognosis Study**

Cardiac event rate curves from a study of 100 patients in which the presence of abnormal CCTA without stenosis was associated with an increased event rate compared with patients with normal CCTA, and an increase in risk is suggested in the mildly abnormal CCTA group. CAD = coronary artery disease; CCTA = coronary computed tomography angiography. Adapted with permission from J Am Coll Cardiol 2007;49:62–70.

contrast agents, and "coregistered, multimodality imaging" are likely to prove of importance in guiding management by optimally depicting structure, function, and biological activity of cardiac tissues.

The next annual Scientific Sessions of the Society of Cardiovascular CT will be held in Orlando, Florida, July 18 to 20, 2008. Scientific abstracts will be published in the *Journal of Cardiovascular Computed Tomography*, with an anticipated due date of approximately April 1, 2008.

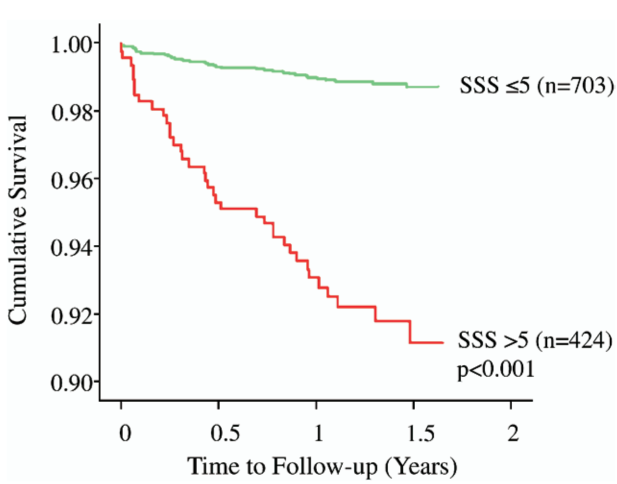

Figure 11 **Cumulative Survival in Patients With SSS ≤5 and >5**

Risk-adjusted controlling for age, family history and dyslipidemia. SSS = segment stenosis score. Adapted with permission from J Am Coll Cardiol 2007;50:1161–70.

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